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Working Paper 23-03

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# The Credit Supply Channel of Monetary Policy Tightening and its Distributional Impacts

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## Abstract

This paper studies how tightening monetary policy transmits to the economy through the mortgage market and sheds new light on the distributional consequences at both the individual and regional levels. We find that mortgage supply factors, specifically restrictions on the debt-to-income (DTI) ratio, account for the majority of the decline in mortgages. These effects are even more pronounced for young and middle-income borrowers who find themselves excluded from the credit market. Also, regions with historically high DTI ratios exhibited greater reductions in mortgage originations, house prices, and consumption.

**Keywords:** interest rates · mortgage lending · house prices · debt-to-income (DTI)

**JEL Classification:** G21 · E43 · G51

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# 1 Introduction

The surge in inflation starting in mid-2021, which reached more than 8% in the US, and the resulting tightening of monetary policy in the US and around the globe have reignited interest in understanding to what extent contractionary measures of monetary authorities are effective in curbing inflation, which appeared more stubborn than initially thought. In most macro models, higher interest rates curb aggregate demand by discouraging the demand for credit and consumption (e.g. Smets and Wouters (2007)). However, higher interest rates can also influence credit supply by tightening borrowing constraints that limit a household's debt-to-income (DTI) ratio, or the ratio of monthly debt payments to income (Greenwald (2018)). This paper provides novel evidence highlighting how contractionary monetary policy transmits to the economy through the mortgage market and sheds new light on the distributional consequences at the individual and regional levels.

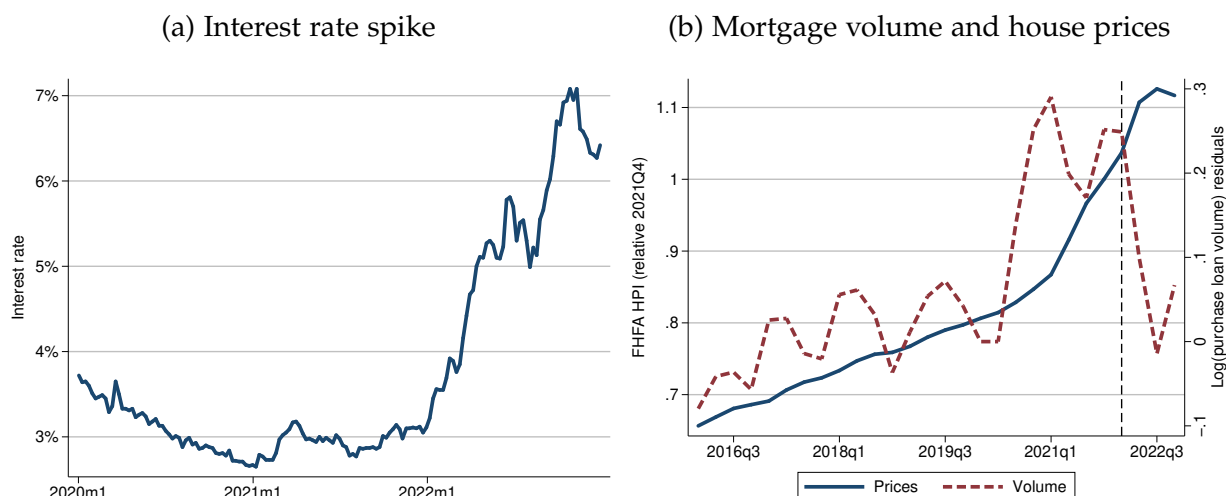
Understanding the path of monetary policy from mortgage credit issuance to consumption and house prices requires being able to distinguish between demand and supply factors. If an increase in interest rates primarily works by decreasing credit demand, then households' elasticity of intertemporal substitution is the main determinant of monetary policy effectiveness. In contrast, if it works primarily by tightening credit supply constraints, then its effectiveness is determined by the degree to which the constraints are binding. In an environment with binding DTI constraints, monetary policy can be significantly more effective, which has implications for macroprudential regulations that might complement it (Greenwald (2018)).

Starting from December of 2021 and in response to the surge in inflation, the US Federal Reserve increased the short term (overnight) interest rates from about 0 to 4 percent. During the same time, it also reduced the size of its balance sheet by about \$214 billion. These measures resulted in an unprecedented rise in mortgage rates from about 3 to 7 percent (Figure 1a). By the latter half of the year, purchase mortgage volume contracted by 20% on a year-on-year basis and house price growth sharply decelerated (Figure 1b). This paper shows that mortgage supply factors, particularly limits on DTI ratios, account for the majority of this decline in mortgages.

Using a representative sample of all mortgages originated in 2021 and 2022, we focus on

Figure 1: Interest rates, mortgage volume, and house prices

Figure 1a shows the typical 30-year fixed rate mortgage interest rate according to the Freddie Mac Primary Mortgage Market Survey, retrieved from FRED at the Federal Reserve Bank of St. Louis. Figure 1b shows the all-transactions national house price index from the Federal Housing Finance Agency relative to 2021Q4 (left axis) and the natural logarithm of the number of loans after partialling out the quarter (i.e. 1,2,3 or 4), to account for seasonality, and indicators for 2020Q1 and 2020Q2, to account for fluctuations associated with the onset of the COVID-19 pandemic. Source for mortgage data: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties.



purchase loans for single-family, owner-occupied properties. The first step of our analysis is to show that the spike in interest rates led to a greater tendency for the DTI ratio to exceed the underwriting thresholds. The key question we address is to what extent the shift to higher DTI ratios is a direct consequence of changes in interest rates or changes in households' behavior, i.e., supply versus demand. To do so, we compute the following counterfactual for mortgages originated in 2021. We first compute the counterfactual interest rate as the sum of the observed interest rate at origination and the increase in the Primary Mortgage Market Survey twelve months later. On average, households would have faced an increase of their counterfactual interest rate by 2.4 percentage points, leading to an increase of their counterfactual monthly mortgage payment by \$487 and an increase of their counterfactual DTI by 5.8 percentage points.

We then compare the counterfactual distribution of DTI ratios for loans originated in 2021 with the actual distribution of originated loans in 2022.<sup>1</sup> This comparison can be broken down into three different regions. The first region comprises borrowers with a DTI lower than 42%. These borrowers are unlikely to be affected by supply-side factors because they are far from the underwriting thresholds, the lowest of which is at 45%. In this region we observe a net increase by 4% of 2021 originations, which could reflect the intensive margin response of households' demand for credit (i.e. borrowers apply for a smaller loan and therefore have lower DTI). The second region includes borrowers that are close to the underwriting thresholds. We observe bunching right below this cutoff amounting to 1.9% of 2021 originations, which captures borrowers' responses to supply-side DTI constraints. While the previous two effects capture responses on the intensive margin, the region above the 50% DTI threshold captures the extensive margin response, i.e., borrowers that would not have been able to purchase a home in the counterfactual conditions. We observe a missing mass of borrowers above the cutoff amounting to a net decrease by 18.1% of 2021 observations. Altogether there was a net 12.2% of mortgages relative to 2021 observations.

We also investigate the size of the home purchased by borrowers across 2021 and 2022 and find that, conditional on the income of the borrower, the purchased home size is mostly unchanged across these years. This is consistent with the limited impact of high

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<sup>1</sup>Here the maintained assumption is that in the absence of interest rate hikes, the 2022 mortgage volume and DTI distribution would have been similar to the distribution in 2021. Consistent with this assumption, we find that the DTI thresholds were stable during this period.

interest rates on households' optimal size of the home, and it is consistent with most of the credit decline being driven by supply constraints. Overall, the small demand response we observe is consistent with existing estimates of a small elasticity of mortgage demand to interest rates (DeFusco and Paciorek (2017)) and a small elasticity of intertemporal substitution (Best et al. (2020)).

Next, we investigate whether these effects are heterogeneous; specifically, we ask who the borrowers most affected by the monetary policy tightening are. This is key to understanding the distributional consequences of monetary policy and the potential necessity to complement monetary policy with other measures. We find that young and middle-income borrowers are the most sensitive to interest rate spikes, and DTI constraints are significantly more likely to be binding for these groups. In other words, while borrowers could in principle respond to an interest rate increase by demanding a lower-priced home to be able to obtain a mortgage, we find that a vast majority of young and middle-income borrowers for whom DTI constraints become binding decide to opt out of the housing market. This may inform policymakers about potential homeowner groups that could benefit from new products to ensure monetary policy does not exclude them from homeownership opportunities.

We also find evidence that these effects have aggregate consequences at the regional level. In order to investigate this, we pooled data from 2019 to 2021 and computed the fraction of loans in those years that would have had a counterfactual DTI above 50%. We show that the fraction of borrowers with counterfactual DTI larger than 50% predicts the reduction in both purchase loan growth and house price growth. The effects are robust to controlling for local economic conditions such as employment, housing supply elasticity, and income per capita. We also find that spending declines the most in areas with high DTI. These results suggest that the effects we find at the individual level are relevant for the transmission of monetary policy to the aggregate economy.

This paper contributes to two major themes in the literature. First, it relates to the body of research that examines the impact of mortgage channels on monetary policy, that is, how changes in interest rates affect the real economy through fluctuations in the mortgage markets (e.g., Di Maggio, Kermani, and Palmer (2020), Berger et al. (2021), Beraja et al. (2018)) as well as the implications for consumption (e.g., Di Maggio et al.

(2017)) and house prices (e.g., Larson (2022), Greenwald (2018), Greenwald and Guren (2021)).

Second, this paper adds to the body of research on credit accessibility in the U.S. mortgage market. This literature covers various aspects, such as discretionary screening by lenders for GSE loans (e.g., Bosshardt, Kakhbod, and Kermani (2023)), interest rates (e.g., Ringo (2023)), race (e.g., Bhutta, Hizmo, and Ringo (2021), Bartlett et al. (2022), and Giacoletti, Heimer, and Yu (2022)), regulations (e.g., Fuster, Plosser, and Vickery (2021), Defusco, Johnson, and Mondragon (2020)), repurchases and servicing costs (e.g., Goodman (2017)), fair pricing and credit allocation by region (e.g., Hurst et al. (2016) and Kulkarni (2016)), capacity constraints (e.g., Fuster, Lo, and Willen (2017)).

## 2 What drove the reduction in mortgage lending?

This section infers the behavioral responses of borrowers and lenders to the interest rate spike by comparing the distribution of observed debt-to-income (DTI) ratios for mortgages originated in 2022 with the distribution of counterfactual DTI ratios for mortgages originated in 2021 but hypothetically facing the prevailing interest rates in 2022. After adjusting the interest rate in this way, we observe that the reduction in mortgage volume was almost entirely incident on loans that would have had a DTI ratio above 50%, which is a discrete underwriting threshold specific to credit supply. Adjustments on the intensive margin to reduce the DTI ratio below these thresholds appear to be limited.

### 2.1 Data

We use the National Mortgage Database, which is a proprietary 5% sample of closed-end first-lien mortgages in the US maintained by the Federal Housing Finance Agency and the Consumer Financial Protection Bureau. We focus on purchase loans originated in 2021 and 2022 for single-family (specifically one-unit), owner-occupied, site-built properties.

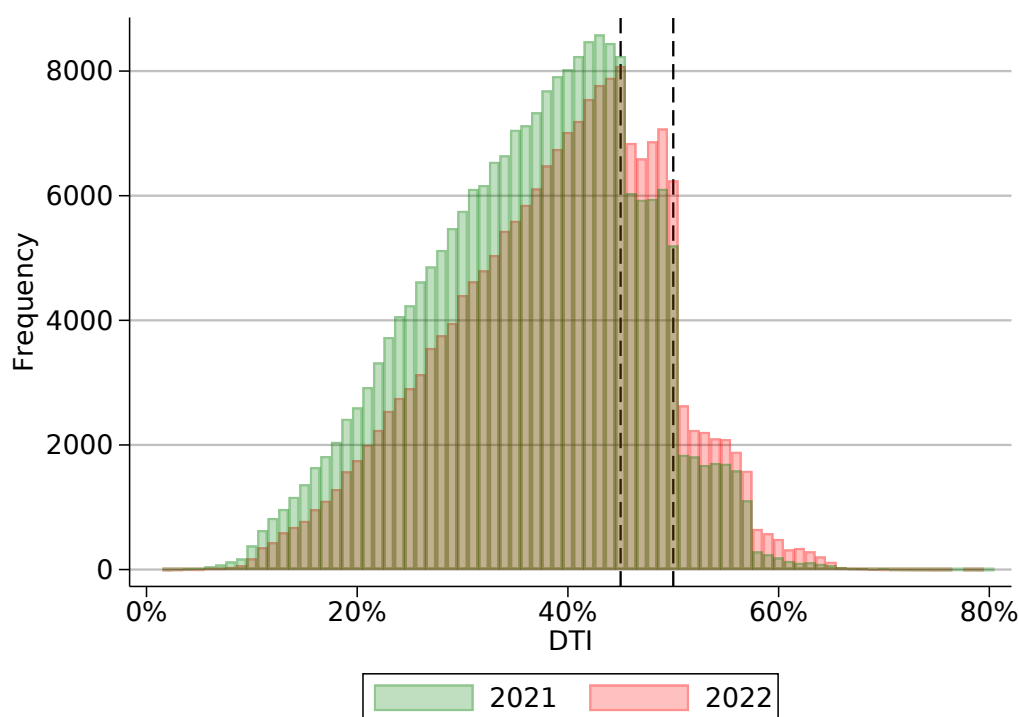
### 2.2 Empirical approach: counterfactual DTI

Our approach is based on the observation that an increase in interest rates directly increases an applicant's probability of being denied credit. In particular, it increases an applicant's mortgage interest payments and, therefore, the DTI ratio, which is equal to the total monthly debt payments divided by monthly income. Consistent with this channel, Figure 2 showing the distribution of DTI in 2021 and 2022 indicates that DTI ratios

generally increased during the interest rate spike. Notably, a greater fraction of loans had a DTI ratio near visible thresholds at 45%, 50%, and 57% where the mass of originations exhibits discrete declines. These thresholds correspond to credit supply limits for various loan programs. In particular, the threshold at 45% appears to be a soft limit for loans acquired by the government-sponsored enterprises (GSEs) Fannie Mae and Freddie Mac, the 50% threshold is an explicit strict limit for GSE loans (Fannie Mae (2022)), and the 57% threshold appears to be a limit associated with FHA loans (see Figure A.1 in Appendix Section A, which shows the DTI distribution for each market segment). However, a drawback of this simple comparison is that it mixes the mechanical effect of the interest rate spike on DTI ratios with the behavioral responses of borrowers and lenders. This observation motivates our construction of a counterfactual DTI for loans originated in 2021 as if they faced the prevailing interest rates in 2022.

Figure 2: Observed DTI distribution

This figure shows the frequencies for each percentage point of the debt-to-income (DTI) ratio for loans originated 2021 to 2022. The distributions are trimmed at a DTI of 80% (omits less than 0.01% of observations). Dashed lines indicate the DTI ratios of 45% and 50%. Source: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties.





We compute the counterfactual DTI for a given loan originated in 2021 as follows:

1. We compute the *counterfactual interest rate* as the observed interest rate plus the percentage point increase in the Freddie Mac Primary Mortgage Market Survey from the month the loan was originated to the same month in 2022, which corresponds to an average increase of 2.4 percentage points. This assumes that the interest rate spike had a relatively level effect across the distribution of interest rates. This assumption is supported by Figure A.2 in Appendix Section A, which shows that the interest rate increased by a similar amount across credit scores.
2. We compute the *counterfactual monthly principal and interest payment* using the standard amortization formula as a function of the loan amount, number of payments, and counterfactual interest rate, which results in an average increase of about \$487.
3. We compute the *counterfactual DTI* as the observed DTI plus the increase in the principal and interest payment divided by monthly income, which results in an average increase of about 5.8 percentage points. We round the counterfactual DTI to the nearest percentage point since the recorded DTI in the NMDB is also rounded. The counterfactual DTI captures the direct effect of changes in the interest rate while holding constant other contributing factors, such as taxes, insurance, and other fixed payments.

Since both distributions now reflect the mechanical effects of the mortgage interest rate spike on DTI ratios, differences between them therefore correspond to the behavioral responses of consumers and lenders. The attribution of these differences specifically to the interest rate spike then depends on the assumption that the two years are otherwise sufficiently similar. Importantly, Figure 2 indicates no notable changes in the major DTI thresholds.

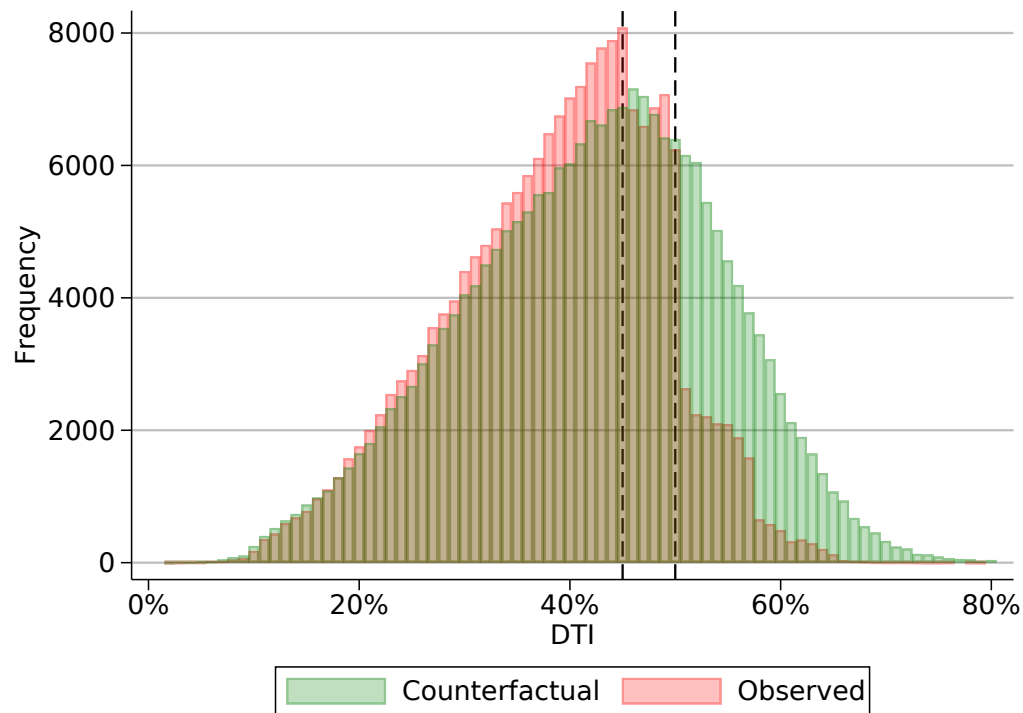
## 2.3 Results

Figure 3 shows the frequencies of the counterfactual DTI in 2021 and the observed DTI in 2022. We focus on three subsets based on the proximity to the DTI thresholds.

First, for DTI ratios up to around 42%, borrowers are unlikely to be directly affected by the DTI thresholds. In this region, the two distributions are mostly similar, with

Figure 3: Observed and counterfactual DTI distributions

This figure shows the frequencies for each percentage point of the debt-to-income (DTI) ratio for loans originated 2021 to 2022. The 2022 distribution is based on the observed DTI, while the 2021 distribution is based on the counterfactual DTI that a loan would have had if it was originated in the same month of 2022, as described in further detail in Section 2.2. The distributions are trimmed at a DTI of 80% (omits less than 0.2% of observations). Dashed lines indicate the DTI ratios of 45% and 50%. Source: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties.



the number of loans increasing by about 4% of the total number of 2021 originations. This modest increase could possibly reflect demand-driven adjustments on the intensive margin as some borrowers that would have been from the dense part of the distribution might have shifted to smaller loans to counterbalance the higher interest payments, although the exact interpretation of these loans is not critical for this analysis.

Second, for DTI ratios from around 42% to 45%, the observed distribution exhibits a clearly greater number of originations, which could be indicative of a supply-driven intensive margin adjustment in which borrowers whose DTI ratio would have been higher than 45% purchase a smaller house or put down a larger downpayment to get below the threshold. For DTI ratios from 45% to 50%, a similar pattern possibly holds but to a lesser extent as there is a slightly larger number of originations in the observed distribution for mortgages with DTI of 48% and 49%. Overall, the total difference between the observed and counterfactual distributions in this region also appears to be modest, amounting to around 1.9% of 2021 originations.

Finally, for DTI ratios exceeding 50%, the observed distribution exhibits a notable decline in the number of originations that corresponds to about 18.1% of all 2021 originations. Some of these borrowers may have adjusted on the intensive margin, in which case they would be counted in the excess number of loans in the observed DTI distribution. The remainder would then correspond to the extensive margin effect, and it comes out to about 12.2% of 2021 originations. Overall, the observation that almost all of the reduction in originations sharply occurs above the 50% underwriting threshold is consistent with a substantial credit supply channel.

### 3 Which borrowers were most impacted?

This section presents some basic facts about which types of borrowers experienced the most pronounced reductions in credit during the mortgage interest rate spike. It also shows limited evidence of borrowers adjusting on the intensive margin.

Figure 4 summarizes changes in borrower, loan, and property characteristics during the mortgage interest rate spike.<sup>2</sup> In terms of borrower characteristics, the reduction

<sup>2</sup>For reference, Figure B.1 in Appendix Section 3 presents a complementary figure that shows densities for variables that are shown in frequencies in Figure 4 and that shows frequencies for variables that are shown in densities in Figure 4.

in lending was concentrated in households where the mean borrower age is less than about 45 (Figure 4a) as well as households making less than about \$100,000 annually (Figure 4b). Figure B.3 in Appendix Section B shows a clear negative association between income and the fraction of households with DTI above the thresholds, consistent with these thresholds driving the disproportionate impact on middle-income borrowers.

In terms of loan and property characteristics, the reduction in lending was most pronounced for loan amounts below around \$300,000 (Figure 4c) and house values below around \$400,000 (Figure 4d). Figure B.3 in Appendix Section B indicates very little tendency for consumers with a given level of income to downsize to a lower house value or loan amount, which is consistent with the evidence of a relatively small intensive margin adjustment effect described in Section 2.

Some characteristics did not appear to change much during the mortgage interest rate spike. In particular, we do not find that the reduction in lending was clearly associated with changes in credit scores (Figure B.1f) or non-mortgage debt to income (Figure B.1e), which we obtain as the back-end DTI ratio minus the front-end payment-to-income ratio. The latter finding is also consistent with borrowers exhibiting relatively little intensive margin adjustments to accommodate the mortgage interest rate spike.

Finally, Figure B.2a indicates that there was generally a reduction of the loan-to-value (LTV) ratio on new originations, which could reflect a combination of higher DTI ratios leading to tighter requirements on LTV ratios to balance out the risk or lessening house price appreciation allowing consumers to achieve a lower LTV without as large a downpayment.

## 4 Local ramifications

This section shows that local economies with higher DTI ratios experienced relative reductions in not only mortgage originations but also house prices and spending.

### 4.1 Empirical approach

We consider the impact of the mortgage interest rate spike on metropolitan statistical areas (MSAs). Exposure to the interest rate spike is represented by the fraction of originations in 2019-2021 where the counterfactual DTI would have been greater than 50% if the loan was originated in the same month in 2022, which we call the “high-DTI

Figure 4: Distributions of borrower characteristics

This figure shows the frequencies or densities of various borrower, loan, and property characteristics in 2021 and 2022. In particular, it shows frequencies for age, income, loan amount, and house value, and it shows densities for non-mortgage debts, credit score, and LTV. The top and bottom 1% of each variable is winsorized in each year. “Age” is the mean age among the borrowers. “Income” is annual household income. “Loan amount” is self-explanatory. “House value” is the minimum of the sale price and appraised value. “Non-mortgage debts” is the back-end debt-to-income ratio minus the front-end payment-to-income ratio and expressed as a percentage of monthly income. “Credit score” is the minimum credit score among the borrowers. “LTV” is the loan-to-value ratio. Source: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties.

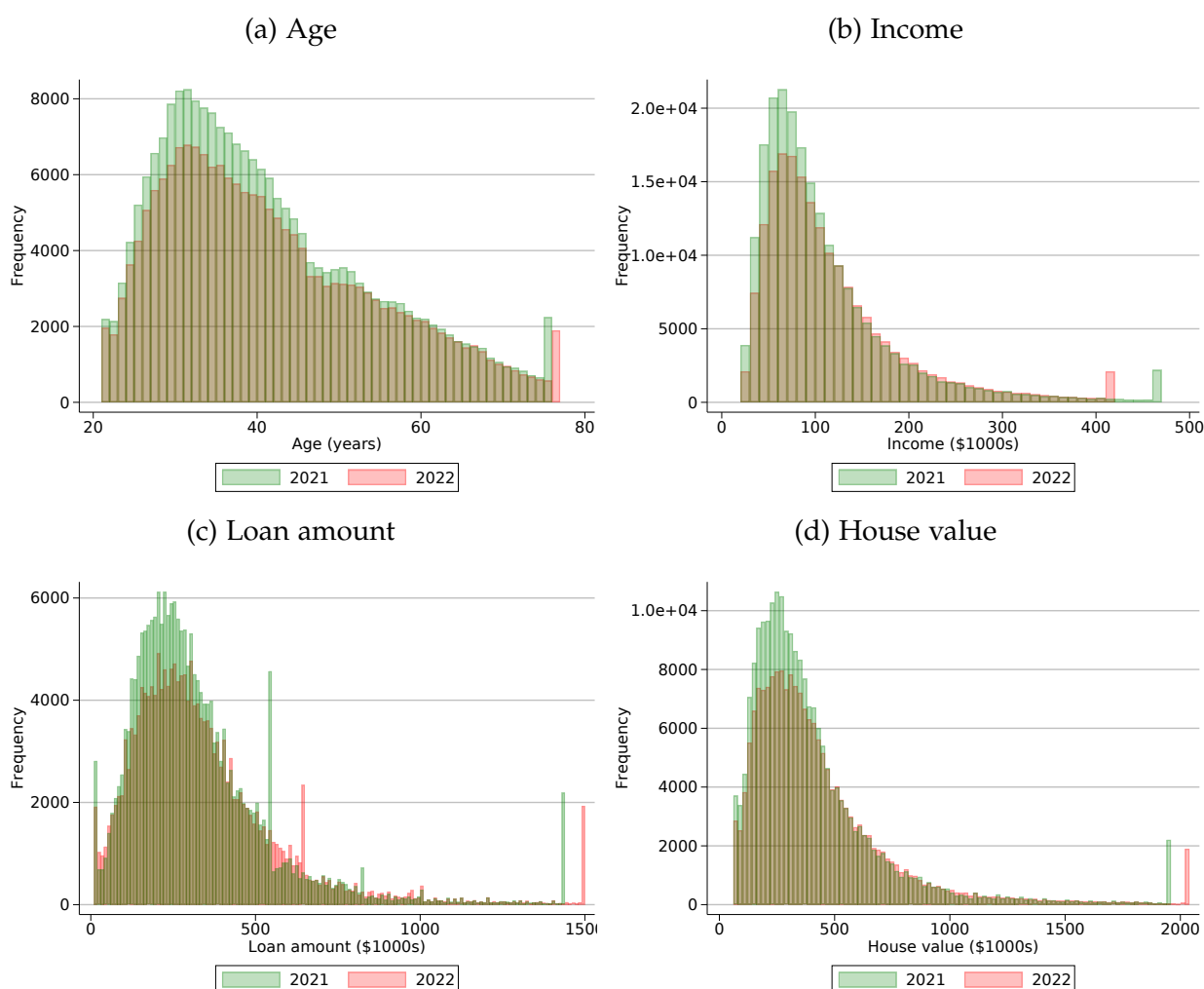
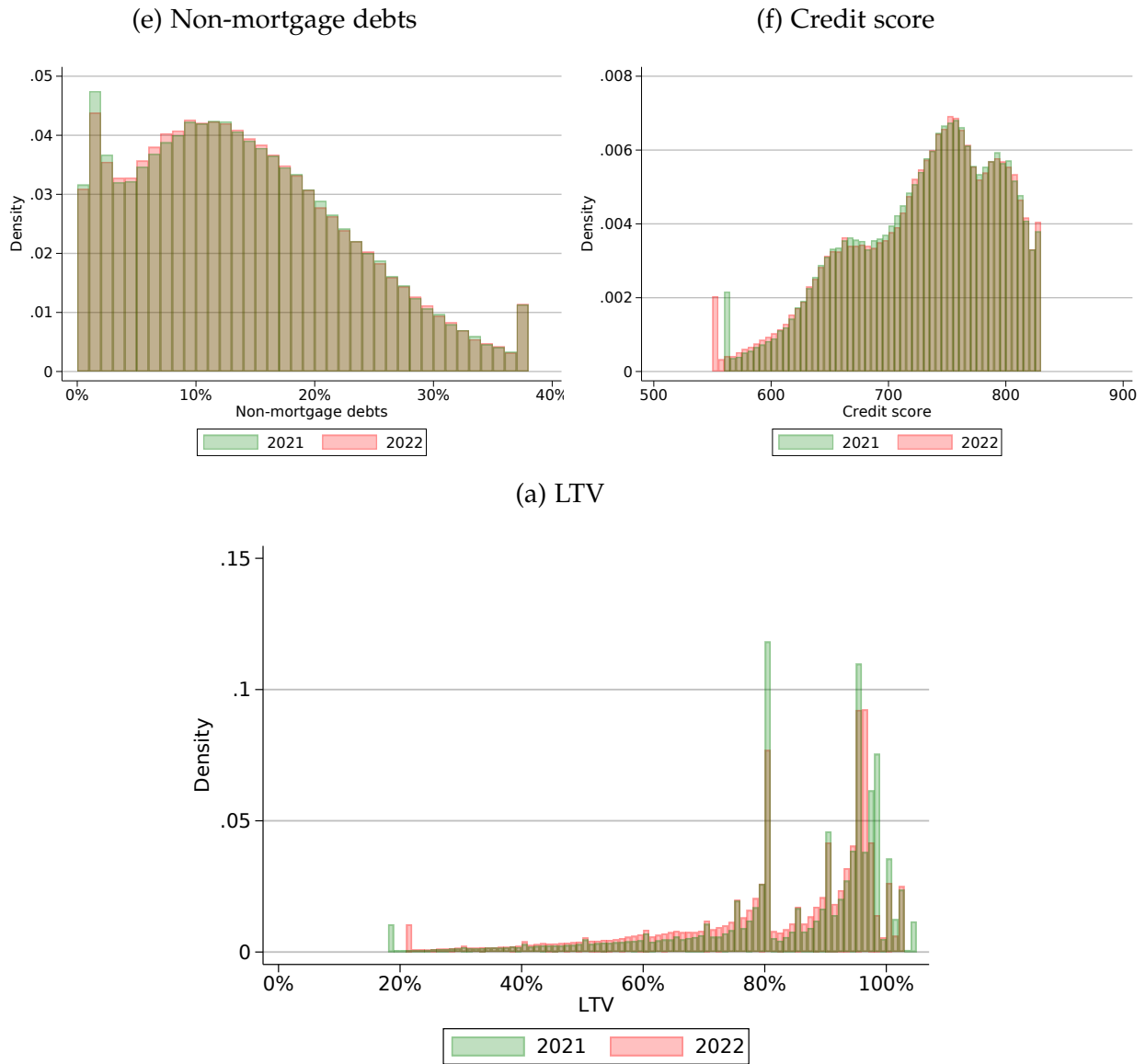


Figure 4: Distributions of borrower characteristics (continued)



share”.<sup>3,4</sup> We run a simple cross-sectional regression:

$$Y_i = \beta_{DTI} highDTI_i + \gamma X_i + \epsilon_i$$

where the  $Y_i$  is the growth from 2021 to 2022 of purchase mortgages, house prices, cash-out mortgages, or spending for MSA  $i$ ,  $highDTI_i$  is the high-DTI share, and the control set  $X_i$  includes the one-year lag of the dependent variable, the growth in the number of employees from 2020 to 2021, and income per capita as of 2021. In some specifications we also include a recent measure of the house supply elasticity based on the Wharton Land Use Regulatory Index (Gyourko, Hartley, and Krimmel (2021)), which reflects such factors as density restrictions and building project review times.

## 4.2 Results

As a testament to the regional relevance of the DTI threshold, Figure C.1 shows via a binned scatterplot that the high-DTI share is clearly associated with lower mortgage growth. In terms of magnitudes, column (1) of Table 1 shows that a 1 percentage point increase in the high-DTI share is associated with approximately a 0.4 percentage point decline in purchase loan growth. The remaining columns show that this result is similar in magnitude and statistical significance when including the controls other than the housing supply elasticity (Column (2)), adding the housing supply elasticity to the controls (Column (3)), and weighting by population (Column (4)). Figure C.1 and Table C.1 in Appendix Section C shows that the results are similar when using the 45% DTI threshold.

Table 2 show that the high-DTI share was also associated with lower house price growth from 2021Q4 to 2022Q4, as measured by the FHFA all-transactions index. This result jointly links existing finding in the literature showing that house price growth is negatively associated with either reductions in transaction volume (DeFusco, Nathanson, and Zwick (2022) or increases in interest rates (Larson (2022)). Table C.2 in Appendix Section C shows that the results are similar when using the 45% DTI threshold.

Table 3 shows that the high-DTI share was associated with lower cash-out refinance growth from 2021 to 2022. This result could be due to a combination of these areas

<sup>3</sup>We show that the results are similar when instead computing the high-DTI share based on the 45% threshold.

<sup>4</sup>We pool 2019-2021 for the MSA analysis in order to have more observations and reduce noise.

Figure 6: High-DTI share and purchase loan growth

This figure presents an MSA-level binned scatterplot of the growth in the total dollar volume of purchase mortgage originations from 2021 to 2022 on the high-DTI share, which is defined as the fraction of originations in 2021 having a counterfactual DTI greater than 50%. The counterfactual DTI is the DTI a loan would have if it was originated in the same month in 2022, as described further in Section 2. Source: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties.

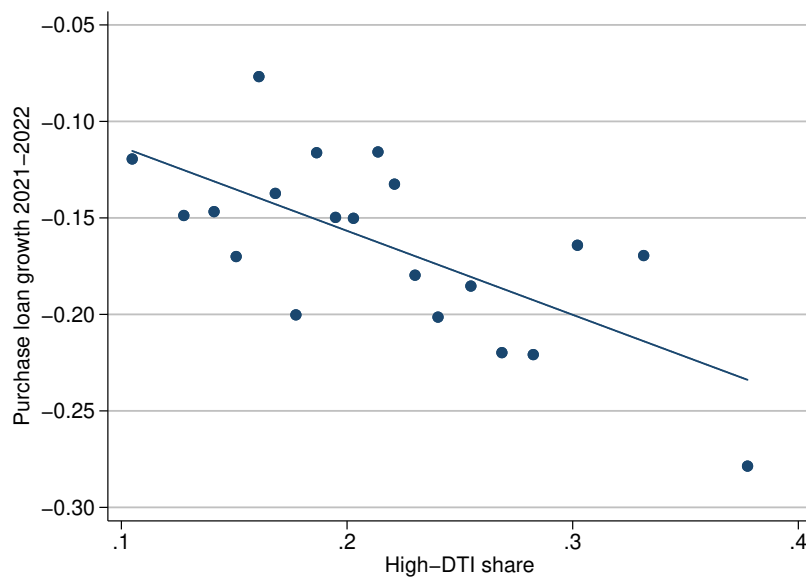




Table 1: High-DTI share and purchase loan growth

	(1)	(2)	(3)	(4)
High-DTI share	-0.407*** (-3.58)	-0.435*** (-3.99)	-0.493*** (-4.62)	-0.587*** (-6.84)
Observations	370	370	291	291
$R^2$	0.038	0.143	0.152	0.228
DTI type	CDTI>50%	CDTI>50%	CDTI>50%	CDTI>50%
Base controls	No	Yes	Yes	Yes
Elasticity	No	No	WRLURI	WRLURI
Weighted	No	No	No	Yes

Note: Column (1) regresses the MSA-level growth in the total dollar volume of purchase mortgage originations from 2021 to 2022 on the high-DTI share, which is defined as the fraction of originations in 2021 having a counterfactual DTI (CDTI) greater than 50%. The counterfactual DTI is the DTI a loan would have if it was originated in the same month in 2022, as described further in Section 2. Column (2) adds control variables: the growth of purchase loan volume from 2020 to 2021 (lagged dependent variable), the growth in the number of employees from 2020 to 2021 (from the County Business Pattern data provided by the US Census Bureau), and inflation-adjusted income per capita as of 2021 (from the American Community Survey). Column (3) adds the Wharton Land Use Regulatory Index (WRLURI) from Gyourko, Hartley, and Krimmel (2021) as a measure of housing supply elasticity. Column (4) weights by population as of the 2020 census. T-statistics computed using robust standard errors are reported in parentheses. \* indicates statistical significance at the 10% level, \*\* indicates significance at the 5% level, and \*\*\* indicates significance at the 1% level. Source for mortgage data: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties.

Table 2: High-DTI share and house price growth

	(1)	(2)	(3)	(4)
High-DTI share	-0.028 (-0.80)	-0.123*** (-3.06)	-0.115*** (-2.74)	-0.076 (-1.30)
Observations	368	368	290	290
$R^2$	0.002	0.134	0.134	0.150
DTI type	CDTI>50%	CDTI>50%	CDTI>50%	CDTI>50%
Base controls	No	Yes	Yes	Yes
Elasticity	No	No	WRLURI	WRLURI
Weighted	No	No	No	Yes

Note: Column (1) regresses the MSA-level growth of the FHFA all-transactions house price index from 2021Q4 to 2022Q4 on the high-DTI share, which is defined as the fraction of originations in 2021 having a counterfactual DTI (CDTI) greater than 50%. The counterfactual DTI is the DTI a loan would have if it was originated in the same month in 2022, as described further in Section 2. Column (2) adds control variables: the growth of purchase loan volume from 2020 to 2021 (lagged dependent variable), the growth in the number of employees from 2020 to 2021 (from the County Business Pattern data provided by the US Census Bureau), and inflation-adjusted income per capita as of 2021 (from the American Community Survey). Column (3) adds the Wharton Land Use Regulatory Index (WRLURI) from Gyourko, Hartley, and Krimmel (2021) as a measure of housing supply elasticity. Column (4) weights by population as of the 2020 census. T-statistics computed using robust standard errors are reported in parentheses. \* indicates statistical significance at the 10% level, \*\* indicates significance at the 5% level, and \*\*\* indicates significance at the 1% level. Source for mortgage data: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties.

experiencing lower house price growth, thereby resulting in less equity to extract, as well as facing underwriting constraints on originating cash-out refinances. Table C.3 in Appendix Section C shows that the results are similar when using the 45% DTI threshold.

Table 3: High-DTI share and cash-out refinance growth

	(1)	(2)	(3)	(4)
High-DTI share	-0.317** (-2.25)	-0.279** (-2.02)	-0.150 (-0.96)	-0.358** (-2.24)
Observations	370	370	291	291
R <sup>2</sup>	0.012	0.089	0.100	0.151
DTI type	CDTI>50%	CDTI>50%	CDTI>50%	CDTI>50%
Base controls	No	Yes	Yes	Yes
Elasticity	No	No	WRLURI	WRLURI
Weighted	No	No	No	Yes

Note: Column (1) regresses the MSA-level growth in the total dollar volume of cash-out refinance originations from 2021 to 2022 on the high-DTI share, which is defined as the fraction of originations in 2021 having a counterfactual DTI (CDTI) greater than 50%. The counterfactual DTI is the DTI a loan would have if it was originated in the same month in 2022, as described further in Section 2. We identify a loan as a cash-out refinance if it is a refinance and the new mortgage is at least 5% more than the previous mortgage. Column (2) adds control variables: the growth of purchase loan volume from 2020 to 2021 (lagged dependent variable), the growth in the number of employees from 2020 to 2021 (from the County Business Pattern data provided by the US Census Bureau), and inflation-adjusted income per capita as of 2021 (from the American Community Survey). Column (3) adds the Wharton Land Use Regulatory Index (WRLURI) from Gyourko, Hartley, and Krimmel (2021) as a measure of housing supply elasticity. Column (4) weights by population as of the 2020 census. T-statistics computed using robust standard errors are reported in parentheses. \* indicates statistical significance at the 10% level, \*\* indicates significance at the 5% level, and \*\*\* indicates significance at the 1% level. Source for mortgage data: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties.

Finally, Table 4 shows that the high-DTI share was associated with lower growth of credit and debit card spending, which is based on data made available by the Economic Tracker associated with Chetty et al. (2022). This is consistent with the lower rate of cash-out refinances, which are an important instrument for consumption out of housing wealth (e.g. Beraja et al. (2018), Di Maggio, Kermani, and Palmer (2020), Berger et al. (2021)). Table C.4 in Appendix Section C shows that the results are similar when using the 45% DTI threshold.

## 5 Conclusion

This paper has three main findings. First, we find that the reduction in purchase loans during the 2022 mortgage interest rate spike was concentrated around underwriting

Table 4: High-DTI share and spending growth

	(1)	(2)	(3)	(4)
High-DTI share	-0.045** (-2.09)	-0.034 (-1.58)	-0.043** (-2.00)	-0.066*** (-2.97)
Observations	343	343	275	275
R <sup>2</sup>	0.010	0.107	0.155	0.216
DTI type	CDTI>50%	CDTI>50%	CDTI>50%	CDTI>50%
Base controls	No	Yes	Yes	Yes
Elasticity	No	No	WRLURI	WRLURI
Weighted	No	No	No	Yes

Note: Column (1) regresses the MSA-level percentage point increase in the yearly average of daily debt and credit card spending relative to early January 6 to February 2nd 2020 from 2021 to 2022 on the high-DTI share, which is defined as the fraction of originations in 2021 having a counterfactual DTI (CDTI) greater than 50%. The counterfactual DTI is the DTI a loan would have if it was originated in the same month in 2022, as described further in Section 2. County-level data on spending is obtained from the Economic Tracker associated with Chetty et al. (2022), which we collapse to MSAs by taking a population-weighted average. Column (2) adds control variables: the growth of purchase loan volume from 2020 to 2021 (lagged dependent variable), the growth in the number of employees from 2020 to 2021 (from the County Business Pattern data provided by the US Census Bureau), and inflation-adjusted income per capita as of 2021 (from the American Community Survey). Column (3) adds the Wharton Land Use Regulatory Index (WRLURI) from Gyourko, Hartley, and Krimmel (2021) as a measure of housing supply elasticity. Column (4) weights by population as of the 2020 census. T-statistics computed using robust standard errors are reported in parentheses. \* indicates statistical significance at the 10% level, \*\* indicates significance at the 5% level, and \*\*\* indicates significance at the 1% level. Source for mortgage data: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties.

thresholds in the DTI ratio, consistent with a substantial credit supply channel. Second, we find that the reduction in lending was relatively pronounced for middle-income and younger borrowers obtaining small- to medium-sized loans for low- to medium-valued properties. We also find little evidence of a reduction in loan amounts, house values, or non-mortgage debts to accommodate higher interest rates. Finally, we find that MSAs with a greater share of the population facing DTI limits upon an increase in interest rates exhibited greater reductions in house prices and spending, suggesting that the DTI-based credit supply channel of the mortgage interest rate spike had implications for local economic outcomes beyond just mortgage originations.

## References

- Bartlett, Robert, Adair Morse, Richard Stanton, and Nancy Wallace.** 2022. “Consumer-lending discrimination in the FinTech Era.” *Journal of Financial Economics*, 143(1): 30–56.
- Beraja, Martin, Andreas Fuster, Erik Hurst, and Joseph Vavra.** 2018. “Regional Heterogeneity and the Refinancing Channel of Monetary Policy.” *The Quarterly Journal of Economics*, 134(1): 109–183.
- Berger, David, Konstantin Milbradt, Fabrice Tourre, and Joseph Vavra.** 2021. “Mortgage Prepayment and Path-Dependent Effects of Monetary Policy.” *American Economic Review*, 111(9): 2829–2878.
- Best, Michael Carlos, James S. Cloyne, Ethan Ilzetski, and Henrik J. Kleven.** 2020. “Estimating the Elasticity of Intertemporal Substitution Using Mortgage Notches.” *The Review of Economic Studies*, 87(2): 656–690.
- Bhutta, Neil, Aurel Hizmo, and Daniel Ringo.** 2021. “How Much Does Racial Bias Affect Mortgage Lending? Evidence from Human and Algorithmic Credit Decisions.”
- Bosshardt, Joshua, Ali Kakhbod, and Amir Kermani.** 2023. “The Value of Intermediaries for GSE Loans.” FHFA Working Paper 23-01.
- Chetty, Raj, John N. Friedman, Nathaniel Hendren, Michael Stepner, and The Opportunity Insights Team.** 2022. “The Economic Impacts of COVID-19: Evidence from a New Public Database Built Using Private Sector Data.” NBER Working Paper 27431.

- DeFusco, Anthony A. and Andrew Paciorek.** 2017. "The Interest Rate Elasticity of Mortgage Demand: Evidence from Bunching at the Conforming Loan Limit." *American Economic Journal: Economic Policy*, 9(1): 210–240.
- DeFusco, Anthony A., Charles G. Nathanson, and Eric Zwick.** 2022. "Speculative dynamics of prices and volume." *Journal of Financial Economics*, 146(1): 205–229.
- Defusco, Anthony A, Stephanie Johnson, and John Mondragon.** 2020. "Regulating Household Leverage." *The Review of Economic Studies*, 87(2): 914–958.
- Di Maggio, Marco, Amir Kermani, and Christopher J. Palmer.** 2020. "How Quantitative Easing Works: Evidence on the Refinancing Channel." *The Review of Economic Studies*, 87(3): 1498–1528.
- Di Maggio, Marco, Amir Kermani, Benjamin J. Keys, Tomasz Piskorski, Rodney Ramcharan, Amit Seru, and Vincent Yao.** 2017. "Interest Rate Pass-Through: Mortgage Rates, Household Consumption, and Voluntary Deleveraging." *American Economic Review*, 107(11): 3550–3588.
- Fannie Mae.** 2022. "Selling Guide: B3-6-02, Debt-to-Income Ratios (5/04/2022)." <https://selling-guide.fanniemae.com/Selling-Guide/Origination-thru-Closing/Subpart-B3-Underwriting-Borrowers/Chapter-B3-6-Liability-Assessment/1032992131/B3-6-02-Debt-to-Income-Ratios-02-05-2020.htm>. Accessed on 3/22/2023.
- Fuster, Andreas, Matthew Plosser, and James Vickery.** 2021. "Does CFPB Oversight Crimp Credit?" Federal Reserve Bank of New York Staff Reports, no. 857.
- Fuster, Andreas, Stephanie H. Lo, and Paul S. Willen.** 2017. "The Time-Varying Price of Financial Intermediation in the Mortgage Market." NBER Working Paper 23706.
- Giacoletti, Marco, Rawley Heimer, and Edison G. Yu.** 2022. "Using High-Frequency Evaluations to Estimate Disparate Treatment: Evidence from Mortgage Loan Officers." Working Paper.
- Goodman, Laurie.** 2017. "Quantifying the Tightness of Mortgage Credit and Assessing Policy Actions." *Boston College Journal of Law & Social Justice*, 37(2): 235–265.
- Greenwald, Daniel L.** 2018. "The Mortgage Credit Channel of Macroeconomic Transmission." Working Paper.

- Greenwald, Daniel L. and Adam Guren.** 2021. “Do Credit Conditions Move House Prices?” Working Paper.
- Gyourko, Joseph, Jonathan S. Hartley, and Jacob Krimmel.** 2021. “The local residential land use regulatory environment across U.S. housing markets: Evidence from a new Wharton index.” *Journal of Urban Economics*, 124.
- Hurst, Erik, Benjamin J. Keys, Amit Seru, and Joseph Vavra.** 2016. “Regional Redistribution through the US Mortgage Market.” *American Economic Review*, 106(10): 2982–3028.
- Kulkarni, Nirupama.** 2016. “Are Uniform Pricing Policies Unfair? Mortgage Rates, Credit Rationing, and Regional Inequality.” Working Paper.
- Larson, William D.** 2022. “Effects of Mortgage Interest Rates on House Price Appreciation: The Role of Payment Constraints.” FHFA Working Paper 22-04.
- Ringo, Daniel.** 2023. “Monetary Policy and Home Buying Inequality.” Federal Reserve Board Finance and Economics Discussion Series 2023-006.
- Smets, Frank and Rafael Wouters.** 2007. “Shocks and Frictions in US Business Cycles: A Bayesian DSGE Approach.” *The American Economic Review*, 97(3): 586–606.

# Appendix

## A Supplemental material for Section 2

Figure A.1: Observed DTI distribution by market segment

This figure shows the frequencies for each percentage point of the debt-to-income (DTI) ratio for loans originated 2021 to 2022 in each market segment: loans insured by the Federal Housing Administration (FHA), loans purchased securitized by government-sponsored enterprises (GSE), loans retained in portfolio or securitized in the private market (Private), loans insured by the US Department of Agriculture (USDA), and loans insured by the US Department of Veterans Affairs (VA). The distributions are trimmed at a DTI of 80% (omits less than 0.01% of observations). Dashed lines indicate the DTI ratios of 45% and 50%. Source: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties.

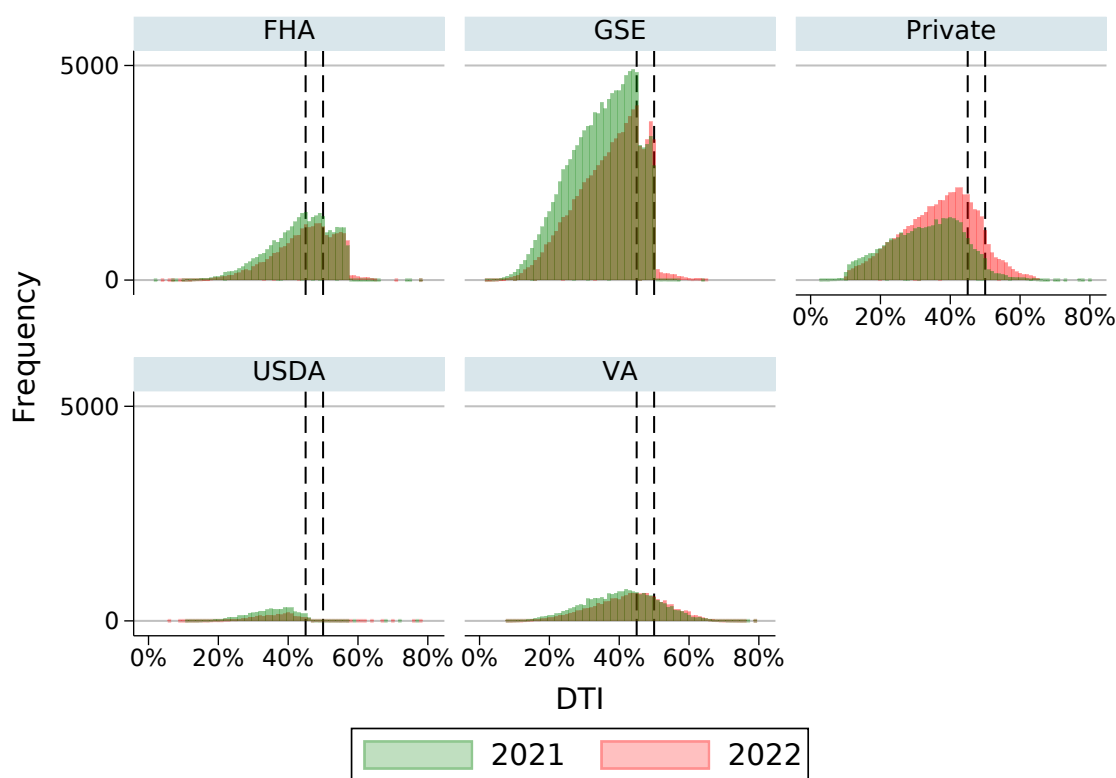




Figure A.2: Interest rate and credit score

This figure shows binned scatterplots of interest rate on the credit score (specifically the minimum credit score among borrowers) in 2021 and 2022. Source: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties.

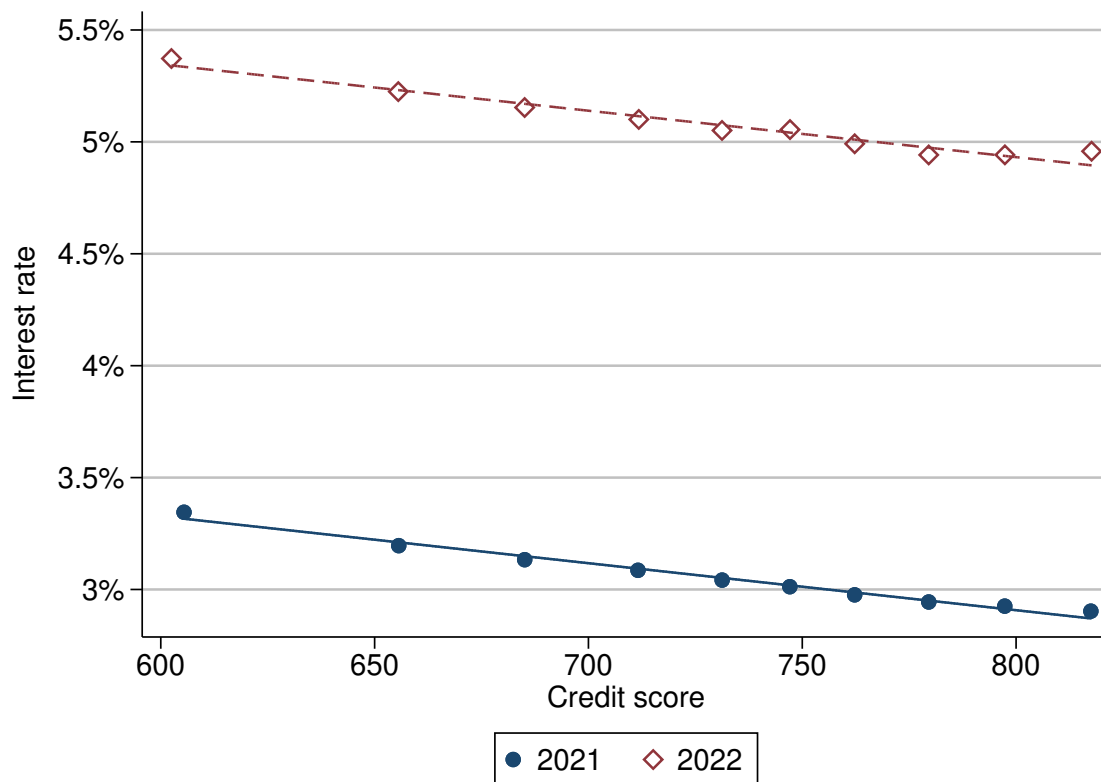
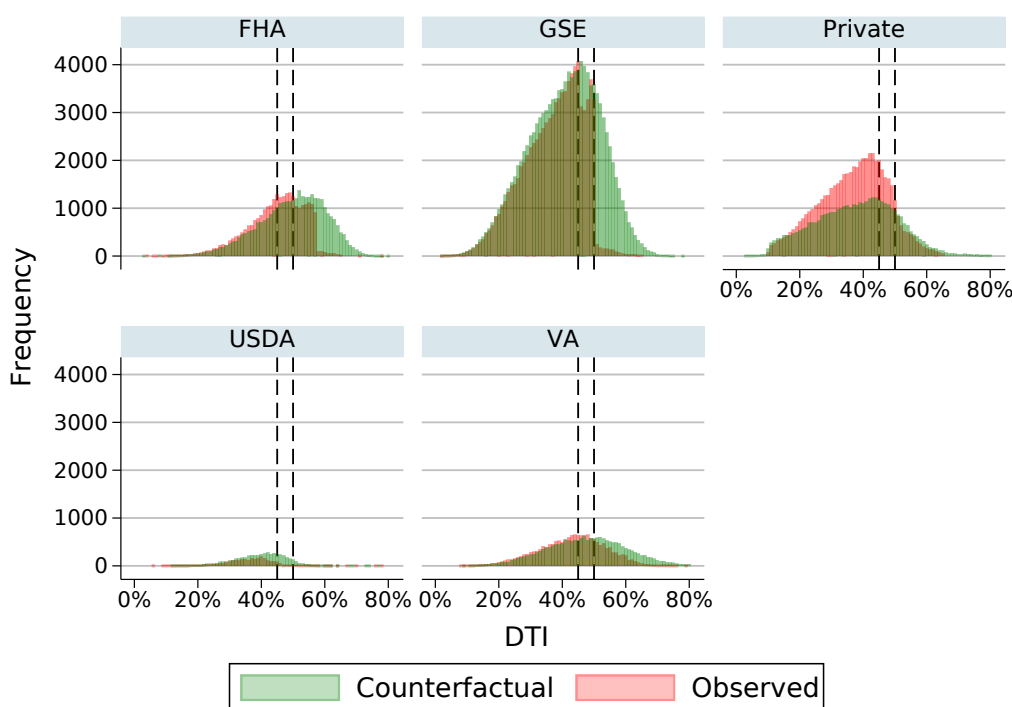


Figure A.3: Counterfactual DTI distribution by market segment

This figure shows the frequencies for each percentage point of the debt-to-income (DTI) ratio for loans originated 2021 to 2022 in each market segment: loans insured by the Federal Housing Administration (FHA), loans purchased securitized by government-sponsored enterprises (GSE), loans retained in portfolio or securitized in the private market (Private), loans insured by the US Department of Agriculture (USDA), and loans insured by the USD Department of Veterans Affairs (VA). The 2022 distribution is based on the observed DTI, while the 2021 distribution is based on the counterfactual DTI that a loan would have had if it was originated in the same month of 2022, as described in further detail in Section 2.2. The distributions are trimmed at a DTI of 80% (omits less than 0.2% of observations). Dashed lines indicate the DTI ratios of 45% and 50%. Source: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties.



## B Supplemental material for Section 3

Figure B.1: Distributions of borrower characteristics (complement to Fig. 4)

This figure shows the frequencies or densities of various borrower, loan, and property characteristics in 2021 and 2022. In particular, it shows densities for variables that are shown in frequencies in Figure 4 (age, income, loan amount, and house value), and it shows frequencies for variables that are shown in densities in Figure 4 (non-mortgage debts, credit score, and LTV). The top and bottom 1% of each variable is winzorized in each year. “Age” is the mean age among the borrowers. “Income” is annual household income. “Loan amount” is self-explanatory. “House value” is the minimum of the sale price and appraised value. “Non-mortgage debts” is the back-end debt-to-income ratio minus the front-end payment-to-income ratio and expressed as a percentage of monthly income. “Credit score” is the minimum credit score among the borrowers. “LTV” is the loan-to-value ratio. Source: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties.

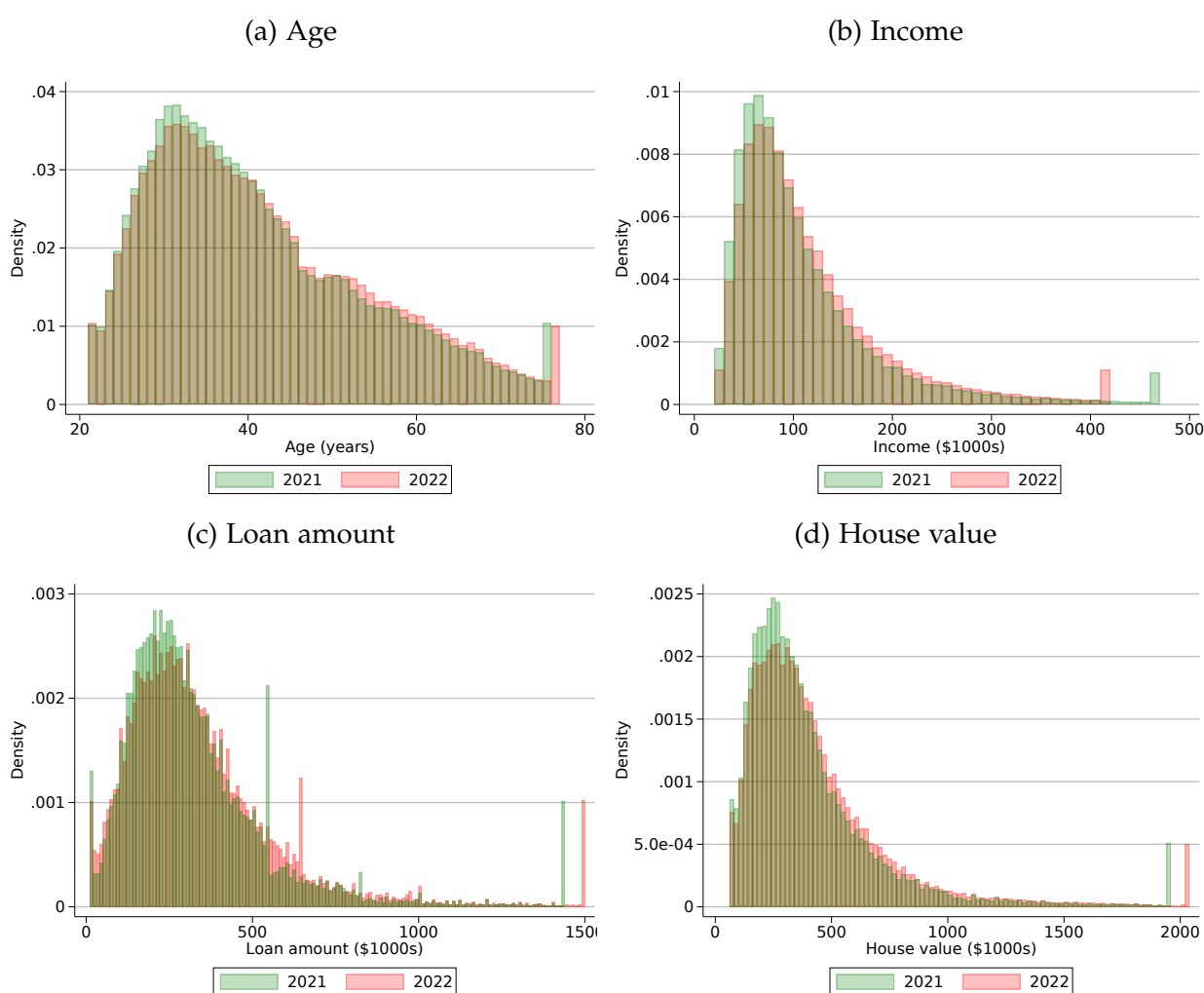


Figure B.1: Distributions of borrower characteristics (continued)

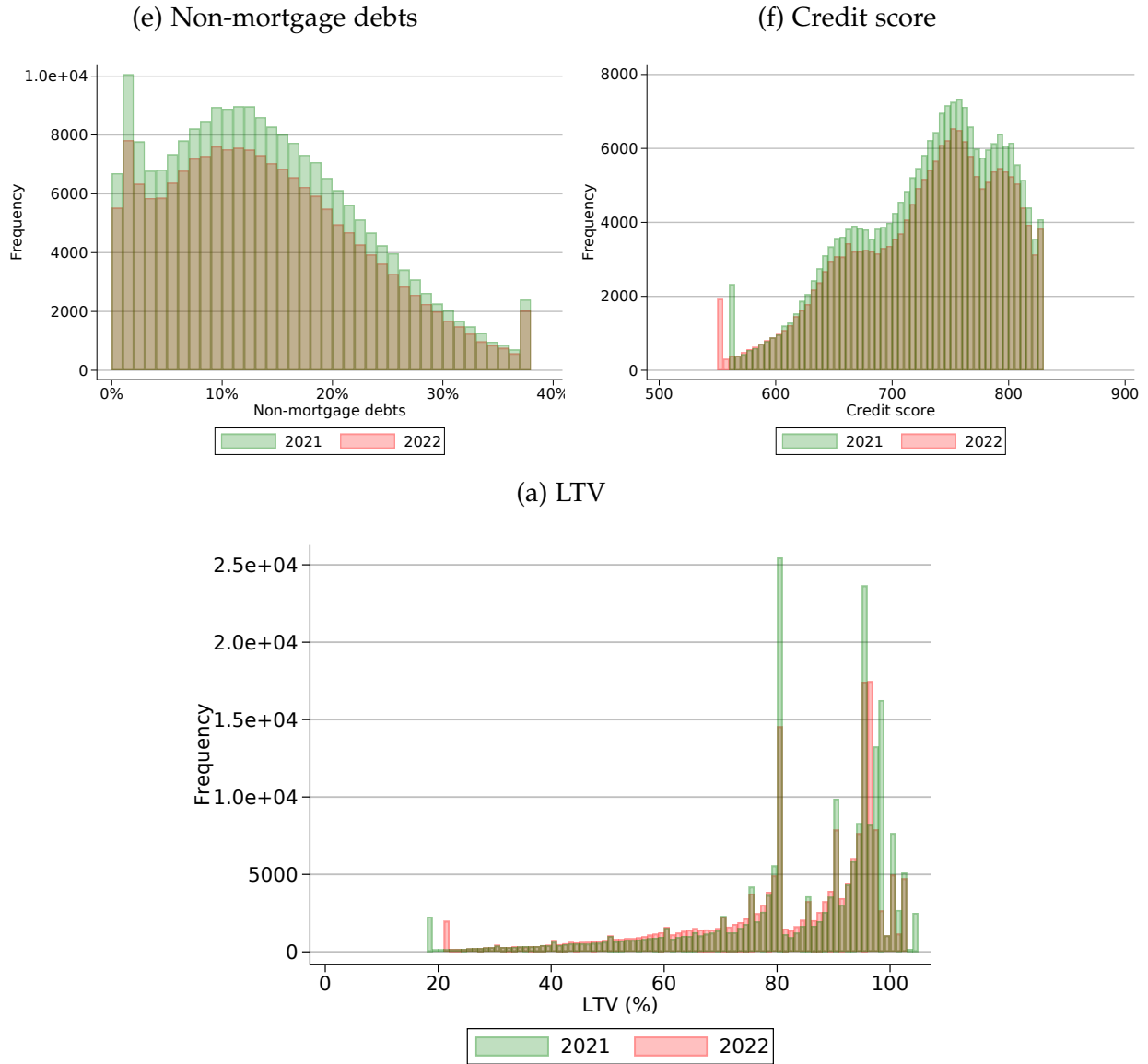


Figure B.3: High counterfactual DTI by age and income

This figure shows a binned scatterplot of an indicator for a loan having a counterfactual DTI (CDTI) above either 45% or 50% on age (B.3a) or income (B.3b). The counterfactual DTI is the DTI a loan would have if it was originated in the same month in 2022, as described further in Section 2. Source: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties.

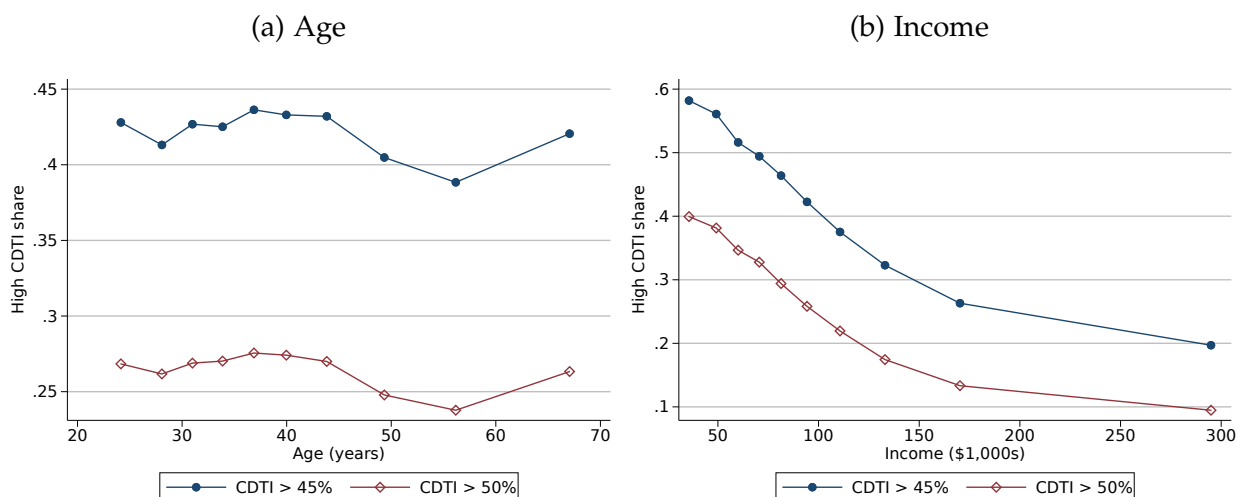
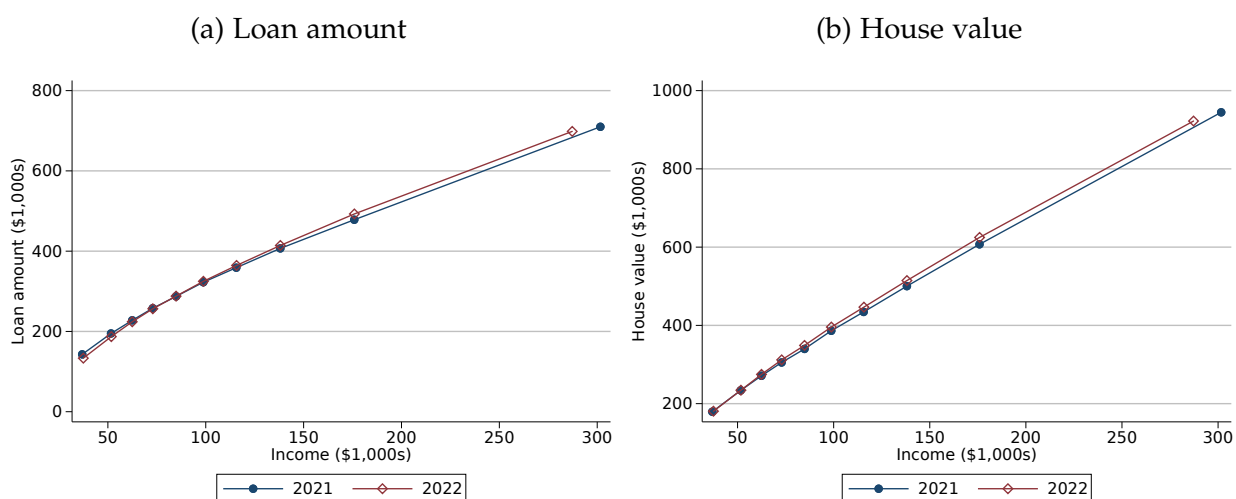


Figure B.4: Loan amount and house value by income

This figure shows a binned scatterplot of loan amount (Figure B.4a) or house value (Figure B.4b) on income in 2021 and 2022. Source: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties.



## C Supplemental material for Section 4

Figure C.1: High-DTI share and purchase loan growth using 45% DTI threshold

This figure presents an MSA-level binned scatterplot of the growth in the total dollar volume of purchase mortgage originations from 2021 to 2022 on the high-DTI share, which is defined as the fraction of originations in 2021 having a counterfactual DTI greater than 45%. The counterfactual DTI is the DTI a loan would have if it was originated in the same month in 2022, as described further in Section 2. Source: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties.

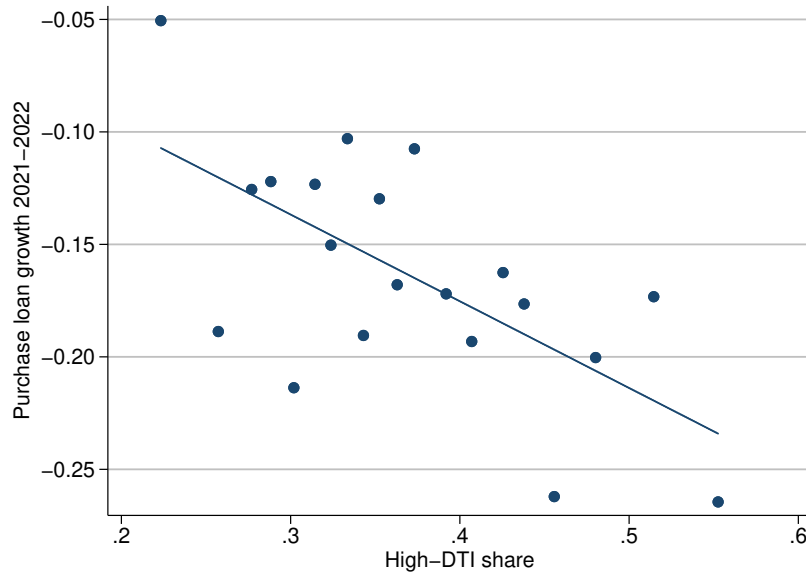


Table C.1: High-DTI share and purchase loan growth using 45% DTI threshold

	(1)	(2)	(3)	(4)
High-DTI share	-0.357*** (-3.88)	-0.386*** (-4.36)	-0.460*** (-5.13)	-0.502*** (-6.76)
Observations	370	370	291	291
$R^2$	0.045	0.152	0.171	0.230
DTI type	CDTI>45%	CDTI>45%	CDTI>45%	CDTI>45%
Base controls	No	Yes	Yes	Yes
Elasticity	No	No	WRLURI	WRLURI
Weighted	No	No	No	Yes

Note: Column (1) regresses the MSA-level growth in the total dollar volume of purchase mortgage originations from 2021 to 2022 on the high-DTI share, which is defined as the fraction of originations in 2021 having a counterfactual DTI (CDTI) greater than 45%. The counterfactual DTI is the DTI a loan would have if it was originated in the same month in 2022, as described further in Section 2. Column (2) adds control variables: the growth of purchase loan volume from 2020 to 2021 (lagged dependent variable), the growth in the number of employees from 2020 to 2021 (from the County Business Pattern data provided by the US Census Bureau), and inflation-adjusted income per capita as of 2021 (from the American Community Survey). Column (3) adds the Wharton Land Use Regulatory Index (WRLURI) from Gyourko, Hartley, and Krimmel (2021) as a measure of housing supply elasticity. Column (4) weights by population as of the 2020 census. T-statistics computed using robust standard errors are reported in parentheses. \* indicates statistical significance at the 10% level, \*\* indicates significance at the 5% level, and \*\*\* indicates significance at the 1% level. Source for mortgage data: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties.

Table C.2: High-DTI share and house price growth using 45% DTI threshold

	(1)	(2)	(3)	(4)
High-DTI share	-0.026 (-0.91)	-0.105*** (-3.27)	-0.105*** (-3.06)	-0.070 (-1.42)
Observations	368	368	290	290
$R^2$	0.003	0.137	0.139	0.151
DTI type	CDTI>45%	CDTI>45%	CDTI>45%	CDTI>45%
Base controls	No	Yes	Yes	Yes
Elasticity	No	No	WRLURI	WRLURI
Weighted	No	No	No	Yes

Note: Column (1) regresses the MSA-level growth of the FHFA all-transactions house price index from 2021Q4 to 2022Q4 on the high-DTI share, which is defined as the fraction of originations in 2021 having a counterfactual DTI (CDTI) greater than 45%. The counterfactual DTI is the DTI a loan would have if it was originated in the same month in 2022, as described further in Section 2. Column (2) adds control variables: the growth of purchase loan volume from 2020 to 2021 (lagged dependent variable), the growth in the number of employees from 2020 to 2021 (from the County Business Pattern data provided by the US Census Bureau), and inflation-adjusted income per capita as of 2021 (from the American Community Survey). Column (3) adds the Wharton Land Use Regulatory Index (WRLURI) from Gyourko, Hartley, and Krimmel (2021) as a measure of housing supply elasticity. Column (4) weights by population as of the 2020 census. T-statistics computed using robust standard errors are reported in parentheses. \* indicates statistical significance at the 10% level, \*\* indicates significance at the 5% level, and \*\*\* indicates significance at the 1% level. Source for mortgage data: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties.



Table C.3: High-DTI share and cash-out refinance growth using 45% DTI threshold

	(1)	(2)	(3)	(4)
High-DTI share	-0.296** (-2.56)	-0.250** (-2.20)	-0.122 (-0.97)	-0.287** (-2.17)
Observations	370	370	291	291
$R^2$	0.015	0.091	0.100	0.149
DTI type	CDTI>45%	CDTI>45%	CDTI>45%	CDTI>45%
Base controls	No	Yes	Yes	Yes
Elasticity	No	No	WRLURI	WRLURI
Weighted	No	No	No	Yes

Note: Column (1) regresses the MSA-level growth in the total dollar volume of cash-out refinance originations from 2021 to 2022 on the high-DTI share, which is defined as the fraction of originations in 2021 having a counterfactual DTI (CDTI) greater than 45%. The counterfactual DTI is the DTI a loan would have if it was originated in the same month in 2022, as described further in Section 2. We identify a loan as a cash-out refinance if it is a refinance and the new mortgage is at least 5% more than the previous mortgage. Column (2) adds control variables: the growth of purchase loan volume from 2020 to 2021 (lagged dependent variable), the growth in the number of employees from 2020 to 2021 (from the County Business Pattern data provided by the US Census Bureau), and inflation-adjusted income per capita as of 2021 (from the American Community Survey). Column (3) adds the Wharton Land Use Regulatory Index (WRLURI) from Gyourko, Hartley, and Krimmel (2021) as a measure of housing supply elasticity. Column (4) weights by population as of the 2020 census. T-statistics computed using robust standard errors are reported in parentheses. \* indicates statistical significance at the 10% level, \*\* indicates significance at the 5% level, and \*\*\* indicates significance at the 1% level. Source for mortgage data: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties.

Table C.4: High-DTI share and spending growth using 45% DTI threshold

	(1)	(2)	(3)	(4)
High-DTI share	-0.038** (-2.04)	-0.030 (-1.63)	-0.036** (-2.08)	-0.057*** (-3.00)
Observations	343	343	275	275
$R^2$	0.011	0.108	0.156	0.216
DTI type	CDTI>45%	CDTI>45%	CDTI>45%	CDTI>45%
Base controls	No	Yes	Yes	Yes
Elasticity	No	No	WRLURI	WRLURI
Weighted	No	No	No	Yes

Note: Column (1) regresses the MSA-level percentage point increase in the yearly average of daily debt and credit card spending relative to early January 6 to February 2nd 2020 from 2021 to 2022 on the high-DTI share, which is defined as the fraction of originations in 2021 having a counterfactual DTI (CDTI) greater than 45%. The counterfactual DTI is the DTI a loan would have if it was originated in the same month in 2022, as described further in Section 2. County-level data on spending is obtained from the Economic Tracker associated with Chetty et al. (2022), which we collapse to MSAs by taking a population-weighted average. Column (2) adds control variables: the growth of purchase loan volume from 2020 to 2021 (lagged dependent variable), the growth in the number of employees from 2020 to 2021 (from the County Business Pattern data provided by the US Census Bureau), and inflation-adjusted income per capita as of 2021 (from the American Community Survey). Column (3) adds the Wharton Land Use Regulatory Index (WRLURI) from Gyourko, Hartley, and Krimmel (2021) as a measure of housing supply elasticity. Column (4) weights by population as of the 2020 census. T-statistics computed using robust standard errors are reported in parentheses. \* indicates statistical significance at the 10% level, \*\* indicates significance at the 5% level, and \*\*\* indicates significance at the 1% level. Source for mortgage data: National Mortgage Database, restricting to purchase loans for one-unit, owner-occupied, site-built properties.